Art. VIII.—*On the Occurrence of Trachyte in Victoria.*

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The term "trachyte" appears to have been introduced by Haüy in 1822 to denote certain igneous rocks which present a rough aspect in hand specimens, but since then the application of the term has been much narrowed down and in the following paper it is employed to describe a small group of igneous rocks of intermediate basicity, in which the dominant felspar is the sanidine variety of orthoclase, and in which the ground-mass, usually holocrystalline, mainly consists of felspar microliths; one or more of the ferro-magnesian minerals—biotite, hornblende and augite—may occur, while apatite, magnetite and zircon are often present. In the normal trachyte free quartz is absent.

Trachyte is of rare occurrence, and, though usually found in rocks of fairly recent origin, is not confined to those rocks, as a fresh augite-bearing trachyte is noted as occurring in rocks of Lower Carboniferous age in the Garlton Hills, Haddingtonshire,[1] and a mica-trachyte of Permian age is reported from Copplestone, near Knowle Hill in Devonshire.[2]

Owing to the interest which attaches to this rock, a brief notice of its occurrence in Australia may not be out of place.

Trachyte is noted in Queensland as occurring at Gladstone, at the Glasshouse Mountains and in the Mackay district.[3] The author of this paper has had—through the kindness of Mr. A. G. Maitland, F.G.S., formerly of the Queensland Geological Survey, and now Government Geologist of Western Australia—the opportunity of studying specimens from the two last mentioned localities. The trachyte from Mount Coonowarin (Crookneck), in the Glasshouse Mountains, is very similar in structure to that

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1 Hatch. Trans. Roy. Soc. Edin. (1892), xxxvii., pp. 115-126.

2 Hatch. Geol. Mag. (1892), p. 250.

3 Jack and Etheridge. Geology and Palæontology of Queensland and New Guinea, pp. 546, 714, 715, and 739.

of the Macedon district in Victoria, to be afterwards described. An analysis of a specimen of trachyte from Gladstone is given by Professor Liversidge in his "Minerals of New South Wales," 1888, p. 229.

Trachyte was discovered in New South Wales in the Coonabarabran district in 1895.[1] This is stated to be the first trachyte found in that colony, but in a paper dealing with "The Cupriferous Tuffs of the passage beds between the Triassic Hawkesbury series and the Permo-carboniferous Coal-measures of New South Wales,"[2] Professor David records a "greyish-purple trachyte lava." No description of the rock is given, and it is possible that the writer was using the term "trachyte" in its older and looser sense. The Rev. J. Milne Curran, F.G.S., in a paper entitled "Microscopic Structure of some Australian Rocks,"[3] had also noted a trachytic lava from the junction of Rocky Bridge Creek and the Lachlan River in New South Wales prior to 1895. From his brief description of the rock it is not clear how he arrived at his determination of the character of the leading felspar. A trachytic tuff is reported from the Manning River.[4]

I have not traced the occurrence of trachyte either in South or Western Australia. At a meeting of the Royal Society of Tasmania, held on 11th April, 1899, a paper was read by Messrs. W. H. Twelvetrees, F.G.S., and W. F. Pettard, F.G.S., describing the occurrence of haüyne-trachyte among the igneous rocks of Port Cygnet and Oyster Cove, Tasmania.

The presence of sanidine in the igneous rocks of Victoria was first noted by Mr. J. Dennant, F.G.S. At the Adelaide meeting of the A.A.A.S., 1893, in a paper entitled "Notes on the Igneous Rocks of South-Western Victoria," he described a series of sanidine-bearing rocks occurring in the district. From the map attached to his paper, it may be seen that these rocks have a very considerable extension. His researches led him to conclude that they were not phonolites, but he does not appear to have recognised their character as trachytes, as in his map they are

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1 G. W. Card. Records of the Geol. Survey of New South Wales, vol. iv., part iii., 1895.
2 Proc. A.A.A.S., vol. i., Sydney, 1887, p. 286.
3 Proc. Roy. Soc. New South Wales, 1891, vol. xxv., pp. 220-221.
4 G. W. Card. Records of the Geol. Survey of New South Wales, vol. v. part i., 1896.

classed as "sanidine and olivine rocks." That among the rocks so named by Mr. Dennant trachyte occurs was pointed out by the present author in a paper on "The Glacial Beds of Toolleen, Coleraine and Wanda Dale," read at the Sydney meeting of the A.A.A.S.. 1898, and the boundaries of the trachyte area in the immediate vicinity of Coleraine are there given.

The object of the present paper is to briefly record the occurrence of trachyte at Macedon, Mount Diogenes (the Camel's Hump), Dryden's Mount (the Hanging Rock) and Brock's Monument, and to make a few observations concerning the trachyte of the Coleraine district. The igneous rocks of the Macedon area are classed in the Quarter Sheet Map No. 6 of the Geol. Survey as "Trap or Hypogene;" the notes attached recognise the variety of igneous rock there displayed but no definite determination of the different rocks and their boundaries is given. An account of the great variety of rock to be found in the Macedon Range may be gathered from Murray's "Geology and Physical Geography of Victoria," page 27.

The first specimen of trachyte which came into my hands was given to me in February, 1895, by Mr. Graham Officer, B.Sc. It was taken from a small quarry near the waterfall on Turritable Creek, to the south-west of the township of Macedon. I visited the Macedon district in September, 1897, and on subsequent occasions, and collected specimens of trachyte between the township and Mount Diogenes, at Mount Diogenes and at Dryden's Mount. My specimens from Brock's Monument I owe to the kindness of Mr. A. E. Kitson, F.G.S., of the Mines Department.

Township of Macedon.—Two types of trachyte occur in the township. The first one to be described may be traced at intervals from the quarry previously mentioned to the summit of Mount Diogenes. It appears probable that the spur on which the township is built may consist entirely of trachyte of this type. In appearance it is a light coloured rock, of granular texture, and contains numerous pink and flesh-coloured crystals of felspar. Under the microscope the base is seen to resolve itself into a mass of felspar microliths, showing marked flow structure, and minute grains of mica and some opaque material which may be mica presenting the phenomenon of absorption. Neither hornblende nor augite can be definitely traced in the

ground mass. The felspar microliths are frequently twinned according to the Carlsbad law, give straight extinction and have very often the rude transverse parting so characteristic of sanidine. Large pellucid phenocrysts of felspar occur, mostly of tabular habit and showing rectangular cleavage lines. As a rule, the crystal boundaries are well marked, though occasionally, when bunches of crystals occur, one or more of the terminal faces may be wanting. In certain of the crystals small irregularly-shaped inclusions, either opaque or of deep brown colour, may be seen. This alteration product appears to start along cracks in the crystal, and is probably caused by the infiltration of iron oxide. The phenocrysts are on the whole very free from included matter; in some the phenomenon of strain-shadows is exhibited. The few crystals of columnar habit which appear in the slide show Carlsbad twinning, with occasionally the broken divisional line due to interpenetration. I have been unable with the means at my disposal to make a suitable measurement of the axial angle of the felspar, so as to at once settle whether it is sanidine or orthoclase, but after comparing it with the sanidine of trachyte from the Drachenfels, Monte di Vetta, Scarrupata and Laach, and of phonolites from many districts, and noting how many of the peculiar characteristics of sanidine it possesses, I see no reason to doubt that the monoclinic felspar of the Macedon rock is sanidine, and that the rock itself must be classed as a trachyte. The other minerals which occur in the rock, magnetite and sphene, do not call for any special notice.

The second type of trachyte which is found in this area differs slightly, both macroscopically and microscopically from that just described. It outcrops on the Turritable Creek near the residence of Mr. R. Harper and may be traced for some short distance up the creek. What exact field relation it bears to the trachyte already described and the igneous rock which constitutes the main rock-mass at the western end of the Macedon Range, I am unable at present to say. It is grey-brown in colour, fine-grained in texture, and shows numerous porphyritic crystals of glassy felspar. Under the microscope the ground mass appears to be made up of felspar microliths, grains of augite, and brown and opaque specks of matter. The felspar microliths are not so perfectly formed as in the rock just

described; they show a tendency to fray out; there are some signs of flow structure. The felspar phenocrysts are sanidine, for the most part idiomorphic: inclusions of apatite and opaque matter are numerous. Small crystals of augite occur with eroded edges; apatite is present in well formed crystals, and there are traces of mica and epidote.

Mount Diogenes (Camel's Hump)—the highest point of the range—is a dome-shaped boss, rising to an altitude of 3500 feet above sea-level. The main mass is composed of a rock very similar in outward appearance to the one first described from Turritable Creek. Under the microscope it is seen that the resemblance extends to the internal structure as well. There is the same fluxion arrangement of felspar microliths around well marked sanidine crystals. Zircon and mica are sparingly developed, and there is some chlorite—probably pseudomorph after hornblende. Between the summit of Mount Diogenes and the augite-felspar rock which forms the western extremity of the range, there is a small outcrop of a rather porous rock showing glassy felspar crystals. The base is an irregular mass of grains and ill-formed crystals of felspar; there is no trace of flow structure. The felspar phenocrysts appear to be sanidine, but they have undergone some alteration; hornblende, zircon, and needles and crystals of apatite are visible in the slide. The rock is an altered trachyte; it has some affinity to the second specimen from Turritable Creek, and may afford a clue to the relation of the trachyte to the other igneous rocks of this part of the range.

Dryden's Mount.—This is the most northerly point of the "trap" area at which I have found trachyte. Dryden's Mount —better known as the Hanging Rock—rises abruptly from the Woodend plateau. It shows a rude columnar structure in places and its shape suggests the remnant of the pipe or neck of an eroded volcano. It is so much weathered that it was a matter of some difficulty to get fresh specimens. The rock has a light-coloured matrix containing black specks and crystals of glassy felspar. The base is mainly composed of grains and minute crystals of felspar having straight extinction and showing only slight flow structure. As in the slides previously described, the base contains numerous specks of mica and opaque material.

The porphyritic felspar appears to be normal sanidine; it contains numerous inclusions, the most common being needles of apatite. Brown hornblende also occurs in phenocrysts, and there are a few crystals of apatite.

Brock's Monument.—I have not visited this locality, but from the Quarter-sheet map it would appear that the igneous rock at this place is intrusive through the Silurian rocks. It is the most easterly point of the Macedon district at which I have found trachyte. In appearance it is a blue-gray compact rock, studded with porphyritic crystals of felspar. Microscopically it bears a strong resemblance to the rock described from Dryden's Mount, the chief point of difference being the presence of augite in addition to hornblende—which latter mineral is much altered—and the relative scarcity of apatite. If the one rock is a trachyte so also is the other.

On the whole it will be seen that trachyte, where it occurs in the Macedon area, is fairly constant both in structure and composition. Glass and free quartz, if present at all, are there in only very minute quantities. Of the geological age of the igneous rocks above described very little is known. They are almost certainly post-Silurian, and from their apparent absence from the boulder-clay so largely developed further north, it seems probable that they were erupted subsequent to the Permo-carboniferous glacial age.

Coleraine District.—Under this title are comprised various localities near Coleraine, for the most part identical with those classed by Mr. Dennant in the map previously referred to. I do not propose to discuss in this present paper their complicated field relations, but merely to indicate a few of the salient features of the trachytes of this district.

A few miles north of Coleraine, and lying just west of the Koonong Wootong Creek, rise two small conical hills, composed of olivine basalt, locally known as Adam and Eve. Through the former of these, on its north side, runs a dyke of light coloured porphyritic rock from west to east. It is from this dyke that I obtained my first specimen of undoubted trachyte in this district. The dyke may be traced west to a low hill where it has been extensively quarried. In the thin slice the phenocrysts of felspar are seen to be monoclinic and of the same type as the felspar in

the Macedon rock and I see no reason to doubt that it is the sanidine varity of orthoclase. The ground mass contains some glass in which are set somewhat short, stout felspars, thus giving the rock the structure designated by Rosenbusch as orthophyric. These minute felspars have well marked crystal boundaries, give straight extinction and show but little tendence to flow arrangement. There is a small quantity of opaque matter disseminated through the base. Apatite is present in rather slender prismatic crystals, but mica, augite and hornblende appear to be absent. The rock must be classed as a trachyte. Possibly its occurrence as a narrow dyke may account for the glass seen in the base.

Further north and on the opposite side of the creek is an outcrop of a rock having a somewhat schistose structure. On examination it is found to consist largely of felspar crystals of columnar habit. In three slides prepared from this rock no glass could be traced, but it may still be there as the dissemination of fine black dust through the base makes the slide somewhat opaque. The matrix of the rock is mainly lath-shaped microliths of felspar arranged somewhat in parallel lines. The felspar phenocrysts are sanidine, showing in almost every case twinning on the Carlsbad law, and very frequently the characteristic rude parting parallel to the face (100). Hornblende is present in grains and ill-formed crystals. Mica, magnetite and apatite may also be traced.

From the low hill lying due north of the Koroit Inn, Coleraine, and just beyond the Koroit Creek, a specimen still more compact in structure and showing smaller porphyritic crystals of felspar was obtained. On slicing it the phenocrysts turned out to be sanidine, while the base was mainly microliths of the same material. Augite quite destitute of crystal boundaries occurs in considerable quantity and magnetite is also present.

A little north of west of the last mentioned hill are several small quarries of what I took to be sandstone. The rock is light gray in colour and medium grained in texture. No phenocrysts can be seen with the naked eye. On slicing the rock I was surprised to find that it is made up almost entirely of felspar crystals. These are monoclinic and on comparison with

the felspars of the rocks previously described from this area I feel no hesitation in classing them as sanidine. Augite and magnetite are present and also a small amount of some secondary chloritic matter.

About two miles east of the town of Coleraine, close to where the Koroit Creek bends west, in a paddock belonging to Mr. W. Young, occurs a hard, dense, black rock of somewhat vitreous lustre. As in the preceding rock, no porphyritic crystals can be noticed, but under the microscope it is seen to be made up largely of felspar microliths showing well marked flow structure. They do not, however, always give straight extinction. The larger felspars are destitute of crystal boundary and appear much eroded; they are sometimes crushed and bent. On the whole I am inclined to regard them as sanidine which has through some physical agency had its characteristic properties somewhat obscured. Augite and magnetite in grains are distributed through the slide. With some diffidence I class this rock—temporarily at least—as a trachyte.

In other places near Coleraine—such as Den Hills and Nareen—rocks somewhat similar to the one last described may be found but in all cases they have undergone so much alteration as to make their determination a matter of some uncertainty.

It will be seen from this description of the Coleraine trachytes that though they present much diversity both of appearance and structure, a regular passage may be traced from the dyke rock in which the sanidine crystals are well developed to the specimen from which phenocrysts of sanidine are absent and in which felspar microliths formed the main part of the mass. It is not clear from the field evidence that all these rocks of trachyte type are of the same geological age but their petrological characters seem to support this view. The discovery by Mr. Dennant in the felspathic tufa on Mount Koroit, near Coleraine, of small blocks containing a Mesozoic cycad—recognised by Mr. Etheridge, junr., as otozamites—may be held to show that, in this part of the field at any rate, there is evidence of either later or post-Mesozoic igneous activity. The field relations of the volcanic cones, Adam and Eve, through which the trachyte is intrusive, suggest that these cones were possibly of submarine origin, and that before extensive denudation had taken place

they were covered by the beds—probably of Miocene age—which form the surface rock over the larger part of the area in which the trachyte is to be found.

A further occurrence of trachyte may be noted at Wanda Dale station, situate about twelve miles N.N.W. of Coleraine. Specimens from this locality contain pellucid sanidine crystals of columnar habit, surrounded by a network of felspar microliths, in which appear granules of hornblende and small specks of magnetite and opaque matter.